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Project Operations
HYDROPOWER MAINTENANCE STANDARDS

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1. Purpose. This Engineering Circular establishes hydropower maintenance practices for all projects delivering hydropower services. It defines the project maintenance plans, maintenance standards, standard maintenance categorization, and maintenance management control that will be included within Chapter 7 of ER 1130-2-510.
2. Applicability. This EC applies to all United States Army Corps of Engineers (USACE) elements and all USACE commands having hydropower operations.
3. Distribution. Approved for public release; distribution unlimited.
4. References.
 - a. ER 1130-2-500, Partners in Support (Work Management Policies)
(https://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1130-2-500.pdf)
 - b. ER 1130-2-510, Hydroelectric Power Operations and Maintenance Policies.
(https://www.publications.usace.army.mil/portals/76/publications/engineerregulations/er_1130-2-510.pdf)
 - c. EP 1130-2-500, Partners and Support Work Management Guidance and Procedures
(https://www.publications.usace.army.mil/Portals/76/Publications/EngineerPamphlets/EP_1130-2-500.pdf?ver=2013-08-22-104517-637)
 - d. EP 1130-2-510, Hydroelectric Power Operations and Maintenance Guidance and Procedures
(https://www.publications.usace.army.mil/Portals/76/Publications/EngineerPamphlets/EP_1130-2-510.pdf)
5. Policy. Chapter 7 of USACE ER and EP 1130-2-5110 will require these hydropower maintenance practices for all USACE Civil Works projects, and requires project-specific maintenance plans, standard maintenance categorization, maintenance management control, and maintenance standards.
6. Project Specific Maintenance Plans.
 - a. The project specific maintenance plans will be based on the maintenance standards defined herein, specific manufacturer's recommendations, and the approved Project Operation and Maintenance Manual.

- b. The project specific maintenance plans will be reviewed and updated at least every 5 years. Updates will also be made within one year of changes in equipment or other events that invalidate details in the plan.

7. Standard Maintenance Categorization.

- a. According to the Guidance provided by the Major Subordinate Command (MSC, also known as the USACE Division Office), all hydropower maintenance and inspection activities will be prioritized in Facilities and Equipment Maintenance system (FEM) to reflect their relative risk and criticality to reliable hydropower generation. These priorities will be used to track maintenance activities and defer work according to the guidance provided by the respective MSC. FEM specifies the following four categories for Job Plans or Work Orders:

1. Deferrable, low priority
2. Normal, for effective operation
3. Urgent, stop eventual loss
4. Critical, stop immediate loss

- b. The four categories of hydropower maintenance are defined as follows:

- (1) Preventive Maintenance - the systematic care, servicing, and inspection of assets, facilities, equipment and components for the purpose of detecting and correcting incipient failures and accomplishing minor maintenance. The frequency of preventive maintenance is generally less than one year.
- (2) Corrective Maintenance - the repair or renewal of an item which has failed or is about to fail. In a mature maintenance organization this Corrective Maintenance work is frequently identified during the performance of Preventive Maintenance work and corrected before an unplanned failure occurs.
- (3) Recurring Maintenance - the replacement or renewal of items that are required on a recurring basis, with a frequency of greater than one year and less than seven to ten years. Examples are painting, floor coverings, engine overhauls, etc. These generally fall below Capital thresholds. These are also the items that are frequently deferred. Recurring Maintenance is sometimes referred to as Cyclic Maintenance.
- (4) Component Renewal - the renewal or replacement of major asset components (roofs, large HVAC, lock gates and mechanisms, spillways gates, etc.). The work almost always exceeds Capital thresholds and generally has a frequency of greater than seven to ten years but is not a capital improvement.

- c. Special types of the above maintenance categories include:

- (1) Predictive Maintenance - a type of Preventive Maintenance that uses a condition based approach where the equipment is monitored and measured to determine when maintenance is needed. It includes evaluation of equipment history, monitoring, analysis, documentation, and benchmark testing to determine imminent equipment operational degradation and the implementation of appropriate repair/replace evaluation. The goal of predictive maintenance is to avoid excessive maintenance while detecting impending failures and repairing or replacing components or equipment before it fails in service.
- (2) Emergency Maintenance - a type of Corrective Maintenance that is required to mitigate a hazard or ensure reliable operation of the facility.

8. Maintenance Management Control.

- a. The computerized maintenance management system at each hydropower project will document all maintenance activities with work orders and should contain the following information:
 - (1) Equipment inventories
 - (2) Repair histories
 - (3) Inspection reports
 - (4) Inspection frequencies
 - (5) Standards for equipment maintenance
- b. The control program for the maintenance management system will include the following:
 - (1) Work order and work completion tracking process.
 - (2) Process for scheduling maintenance.
 - (3) Process for evaluating maintenance efficacy.
 - (4) Process for implementing corrective actions in maintenance practices
 - (5) Process for sharing corrective actions with other projects.

9. Maintenance Standards.

- a. The appendices list standard maintenance tasks for major hydropower equipment and systems along with the standard frequency for performing these tasks. This

information will be used to establish an initial maintenance program, to assess an existing program, and as a basis for comparing programs. Although this information will define the standard, specific manufacturer's maintenance manuals and recommendations, equipment condition and history, criticality, environment, severity of use, and other parameters must be considered when developing a maintenance program and when determining maintenance frequency. Therefore, according to the guidance provided by the respective MSC, tasks and frequencies may be adjusted, if required, to prepare the written project maintenance programs and project-specific maintenance standards.

- b. When practical, the maintenance tasks in each appendix were organized into specific categories, with a "General" category at the top of the list that will apply to each corresponding sub-category shown below. To utilize lists that feature a "General" section, combine the General tasks with the tasks shown for the selected sub-category.
- c. The appendices do not specify "how" to perform the maintenance tasks. Unless specific guidance is provided by the respective MSC, the tasks will be completed using the industry-accepted best practices and in compliance with safety, health and other applicable requirements.
- d. One of five possible frequency categories is assigned for each task in appendices. These categories are: Weekly (W), Monthly (M), Quarterly (Q), Semi-Annual (S), Annual (A), and Periodic (P). The number of years for the Periodic frequency are indicated in the "P" columns. The shortest frequency is shown where more than one of the frequency categories applied to a task.
- e. Follow the guidance provided by the MSC to address equipment and variations not identified within the appendices.
- f. If the appendices show tasks that do not apply to a specific piece of equipment, follow the guidance provided by the MSC to declare the tasks as non-applicable.

FOR THE COMMANDER:

16 Appendixes
(See Table of Contents)



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Appendix A

Air Systems Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR AIR SYSTEMS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
1	Check operation of gauge	X					
2	Drain condensation from bottom of reservoirs/accumulator tanks.		X				
3	Check operation/calibration of pressure/temperature switches.					X	
4	Verify compressor starts unloaded.		X				
5	Check oil pressure & level.		X				
6	Clean or replace air intake filter element.			X			
7	Check belts/chains for tension, wear, and aging.			X			
8	Check pulley clamp bolts & screws for tightness.			X			
9	Record hour meter reading			X			
10	Inspect compressor components for corrosion & fatigue.					X	
11	Check shaft couplings for excessive runout or vibration.					X	
12	Check flow of water or coolant through compressor and aftercooler. Flush as required		X				
13	Thoroughly clean cooling fins of air-cooled compressors and radiators of water-cooled compressors.					X	
14	Replace oil filter as required			X			
15	Check piping for corrosion.					X	
16	Inspect reed valves for condition and correct operation					X	
17	Clean control cabinets and devices.					X	
18	Inspect wiring and connections					X	
19	Check controls for proper operation.					X	
20	Lubricate motor bearings					X	
21	Check crankcase heaters for correct operation					X	
22	Check motor insulation resistance					X	
23	Clean motor cooling fins					X	
24	Perform visual inspection of starters/contactors					X	
25	Measure motor full load amps					X	
26	Infrared scan motor.					X	
27	Check calibration of transducers					X	
28	Check operation of pressure relief valves					X	
29	Check calibration of pressure relief valves					X	
30	Check operation of dryers.		X				
	PRESSURE VESSELS						
1	Drain condensate from air receivers.	X					
2	Inspect receiver tanks.						5
3	Check operation of pressure relief valves					X	
4	Check calibration of pressure relief valves						5
	PIPING						
1	Check regulating valves for correct pressure					X	
2	Exercise isolation valves					X	
3	Check air distribution system for air leaks.			X			
4	Check automatic traps for leaks and proper operation.					X	
5	Clean strainer and check for corrosion or scale buildup.		X				
6	Check pipe hangers and brackets					X	
7	Check operation of gauges.	X					
8	Drain condensation from traps.		X				
9	Calibrate gauges and transducers.					X	

Appendix B

Breaker Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR BREAKERS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
GENERAL							
1	Infrared Scan in normal operating conditions prior to removal from service and in normal operating condition after return to service.					X	
2	Clean insulating components.					X	
3	Record normal operating loads (if equipped with meters)		X				
4	Review Equipment ratings; Current interrupting rating vs. short circuit current analysis; installed vs. drawings; Equip rating vs. Facility Rating (NERC FAC-008-3)					X	
5	Visual inspection (contact wear, foundation, grounds, paint, cracks, leaks, cable terminations, stress cones, evidence of leaks, evidence of tracking, cleanliness, all equipment and connections are in normal operating positions)					X	
6	Mechanical inspection of external screws, bolts, electrical terminals.					X	
7	Operate breaker.				X		
8	Verify correct operation of auxiliary features such as trip and pickup indicators					X	
9	Perform fault load studies and recalculate settings.						5
10	Retorque line side of feeder breakers						2
LOW VOLTAGE CIRCUIT BREAKER (UNDER 600V)							
1	Verify alignment of operating mechanism.					X	
2	Clean and relubricate operating mechanism.					X	
3	Record Number of Operations					X	
4	Perform Contact Resistance Test						2
5	Perform overcurrent fault trip testing and verify settings.						2
6	Perform Insulation Resistance Test						2
7	Check cabinet heaters for proper operation.	X					
8	Clean Unit (Insulating parts, including bushings, should be wiped clean.)					X	
9	Inspect arc chutes.					X	
10	Functional test control circuits & interlocks						2
11	Inspect contact alignment against manufacturer's recommendations.						2
12	Perform visual inspection of removable trip unit					X	
13	Perform Rated Hold-In Test						2
14	Perform Shunt Trip Release Test						2
15	Perform Under-Voltage Trip Release Tests						2
16	Determine long-time pickup and delay by primary current injection.						2
17	Determine short-time pickup and delay by primary current injection.						2
18	Determine ground-fault pickup delay by primary current injection.						2
19	Determine instantaneous pickup current by primary injection.						2
20	Perform minimum pickup voltage test on shunt trip and close coils						2
AIR CIRCUIT BREAKERS							
1	Verify lubrication and alignment of operating mechanism.					X	
2	Record Number of Operations					X	
3	Perform Contact Resistance Test						2
4	Perform Motion analysis / Timing Test						2

PREVENTIVE MAINTENANCE TASKS FOR BREAKERS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
5	Perform overcurrent fault trip testing and verify settings.						2
6	Perform Insulation Resistance Test						2
7	Check cabinet heaters for proper operation.			X			
8	Clean Unit (Insulating parts, including bushings, should be wiped clean.)					X	
9	Inspect Interrupter					X	
10	Functional test control circuits & interlocks					X	
11	Inspect arc chutes.						2
12	Inspect puffer operation.						2
13	Inspect air system.					X	
	VACUUM CIRCUIT BREAKERS						
1	Verify lubrication and alignment of operating mechanism.					X	
2	Record Number of Operations					X	
3	Perform Contact Resistance Test					X	
4	Perform Motion analysis / Timing Test						2
5	Perform overcurrent fault trip testing and verify settings.						2
6	Perform Insulation Resistance Test						2
7	Check cabinet heaters for proper operation.			X			
8	Functional test control circuits & interlocks					X	
9	Measure change in shaft position.					X	
10	Perform vacuum integrity test						2
	OIL CIRCUIT BREAKERS						
1	Verify alignment of operating mechanism.						4
2	Record Number of Operations					X	
3	Perform Contact Resistance Test						2
4	Perform Motion analysis / Timing Test						2
5	Perform overcurrent fault trip testing and verify settings.						2
6	Perform Insulation Resistance Test						2
7	Check cabinet heaters for proper operation.			X			
8	Clean and relubricate operating mechanism.		X				
9	Functional test control circuits & interlocks					X	
10	Clean tank and all other components in contact with oil.						4
11	Test dielectric condition of oil and visually inspect for excessive carbon build up.					X	
12	Inspect and service hydraulic or pneumatic system and/or air compressor.					X	
	SF6 GAS CIRCUIT BREAKERS						
1	Verify lubrication and alignment of operating mechanism.						4
2	Record Number of Operations					X	
3	Perform Contact Resistance Test						2
4	Perform Motion analysis / Timing Test						2
5	Perform overcurrent fault trip testing and verify settings.						2
6	Perform Insulation Resistance Test						2
7	Check cabinet heaters for proper operation.			X			
8	Clean Unit (Insulating parts, including bushings, should be wiped clean.)					X	
9	Inspect Interrupter						2
10	Functional test control circuits & interlocks					X	
11	Perform Contact Resistance Test						2
12	Record gas pressure and temperature; compare with tolerances and prior readings		X				
13	Verify operation and calibration of temperature and pressure switches and gauges					X	

PREVENTIVE MAINTENANCE TASKS FOR BREAKERS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
14	Perform a moisture test on gas						2
15	Overhaul breaker with new seals, contacts, nozzles per mfr recommendation						10
16	Overhaul disconnect, grounding, and breaking switches per mfr recommendation						10
	BUSHINGS						
1	Clean all exterior surfaces					X	
2	Visually inspect for cracks, corrosion, and leaks					X	
3	Inspect gaskets						2
4	Inspect capacitance taps and test electrodes.						2
5	Check oil level.					X	
6	Perform Power Factor Test						2
7	Perform Capacitance Test						2

Appendix C

Bulkhead/Stoplog Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR BULKHEADS/STOPLOGS
 Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
 (Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
1	Check concrete and embedded components for cracks, spalling, or signs of movement					X	
2	Inspect seals and contact surfaces					X	
3	Ensure proper lubrication					X	
4	Inspect for cracks, corrosion, fatigue, damaged welds					X	
5	Operate gate or valve through a complete open-close cycle under balanced conditions					X	
6	Visually inspect all threaded, welded, and flanged fittings, checking for any leaks or corrosion					X	
7	Check condition of cathodic protection					X	
	BULKHEADS/STOPLOGS						
1	Inspect condition of lifting beam					X	
2	Inspect guides					X	
3	Inspect springs and spring pockets					X	
4	Inspect alignment devices					X	
5	Inspect rollers					X	
6	Inspect lifting beam attachment point					X	
	TRASH RACKS						
1	Clean debris from trash rack					X	
2	Verify calibration and operation of head differential pressure transducer					X	
3	Inspect debris removal systems					X	
	GATES						
1	Inspect roller chain assemblies					X	
2	Inspect guide rollers					X	
3	Inspect lifting beam attachment point					X	
	OPERATING MACHINERY						
1	Visually inspect each motor					X	
2	Check all electrical connections.					X	
3	Verify proper lubrication.					X	
4	Measure motor insulation resistance					X	
5	Measure motor full load amps					X	
6	Perform infrared scan					X	
7	Inspect ropes, chains, and cables					X	
8	Inspect gearboxes					X	
9	Inspect hydraulic system for leaks					X	
10	Inspect filter.					X	
11	Perform oil analysis.					X	
12	Verify calibration of gauges, switches, indicators and						3
13	Inspect control and annunciation circuits					X	
14	Inspect hoist brake circuit					X	
15	Inspect brake drums and pads					X	
16	Inspect sheaves and drums					X	
17	Inspect drive machinery					X	

Appendix D

Buswork Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR BUSWORK

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
GENERAL							
1	Infrared Scan in normal operating conditions prior to removal from service and in normal operating condition after return to service.					X	
2	Review Equipment ratings; Current interrupting rating vs. short circuit current analysis; installed vs. drawings; Equip rating vs. Facility Rating (NERC FAC-008-3)					X	
3	Visual Inspection (examine bus assemblies for good condition, check connections for signs of overheating, foundation, grounds, paint, cracks, leaks, cable terminations, stress cones, evidence of leaks, evidence of tracking, cleanliness, all equipment and connections are in normal operating positions)					X	
4	Mechanical Inspection (Check expansion joints or flexible connections for good condition, verify bolted connections, check integrity of electrical connections)					X	
5	Measure & Record the resistance of the station grounding system.					X	
6	[Insulation test] (Hipot or Doble test – power frequency dielectric loss, dc insulation resistance, power factor)						4
7	Clean enclosures					X	
8	Verify operation of busway space heaters	X					
INSULATORS							
1	Inspect for damage, overheating, or tracking.					X	
2	Clean insulators					X	
3	Insulator - dielectric loss test						4
BUSHINGS							
1	Visual Inspection (examine connections for signs of overheating, paint, cracks, leaks, cable terminations, stress cones, evidence of leaks, evidence of tracking, cleanliness, and all equipment and connections are in normal operating positions)					X	
2	Clean bushings					X	
3	Check oil level as applicable		X				
4	Bushings – Insulation test (Doble test – power frequency dielectric loss, dc insulation resistance, power factor)						4
LIGHTNING ARRESTORS							
1	Inspect physical and mechanical condition (anchorage, alignment, and grounding.)					X	
2	Clean the unit					X	
3	Test grounding connection					X	
4	Verify that stroke counter, if present, is correctly mounted and electrically connected.		X				
5	Perform insulation resistance, watts-loss or leakage current test.						4
MEDIUM/HIGH VOLTAGE POWER CABLE BUS							
1	Insulation test (DC ramp test, PF Tip-up test, AC-hipot, DC-hipot, Very Low Frequency (VLF) hipot, Doble PF, partial discharge)						4

PREVENTIVE MAINTENANCE TASKS FOR BUSWORK

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
2	Check insulating oil as applicable— dissolved gas analysis (DGA), physical, and chemical tests					X	
	FORCED-AIR COOLED BUS						
1	Verify Fan rotation and speed		X				
2	Check fan and motor vibration		X				
3	Measure and Record Motor operating voltage and load current		X				
4	Measure and Record heat exchanger coolant flow rate and temperature		X				
5	Verify air balance within the bus system		X				
6	Confirm calibrations/settings for alarm and indicating devices (thermostats, thermometers, pressure switches, etc.)					X	
7	Inspect/replace filters		X				

Appendix E

Crane Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR CRANES

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
GENERAL							
1	Perform inspection and maintenance unique to the crane manufacturer	X					
2	Perform crane load test (100% rated load)						X ¹
3	Check all framework for deformation, cracks, and corrosion, paying close attention to load bearing members and welded joints.					X	
4	On fixed cranes, check column anchorage and supports for deformed bolts or concrete cracks in the baseplate and foundation.					X	
5	Inspect all functional operating mechanisms and their components for excessive wear or damage.		X ²				
6	Verify crane and hoist motions are smooth and regular for all speed steps, with no hesitations, vibration, binding, weaving, unusual noise, or other irregularity.		X ²				
7	Clean the crane cab, inspecting condition of seat, windows, doors, hand and foot controls, etc.		X ²				
8	Inspect the fire extinguisher in the crane cab.		X ²				
9	Verify the crane operation and maintenance log book is being used properly		X ²				
10	With crane in motion, check for abnormal vibration or skewing in the crane support structure, bracing, and crane rails.		X ²				
11	Check condition of handrails and ladders		X ²				
12	Check ladder rungs and stairs for significant wear of antislip surfaces.		X ²				
13	Check that footwalks and toeboards are secure and in good condition		X ²				
15	Inspect stops and bumpers for wear, cracks, corrosion, or distortion.					X	
16	Check for leaking of hydraulic bumpers and fill to proper level.					X	
17	Check rubber or plastic bumpers for cracks or other damage.					X	
18	Verify that all guards are in place and securely fastened.		X ²				
CRANE RAILS							
1	Check rails for alignment and level. Look for dips, cleanness, grease, or oil.					X	
2	Inspect crane rail clips or welds for damage.					X	
3	Check crane rail expansion gaps for uniformity and conformance with spacing tolerances.					X	
4	Inspect for wear on the crane rails, both on the top and side of the rail head.					X	
5	Clean crane rails as needed			X			
6	Check concrete crane rail supports for cracking or spalling					X	
7	Check steel crane rail supports for corrosion and loose bolts or rivets.					X	
8	Inspect crane rail stops					X	
9	Inspect and adjust rail sweeps					X	
CONTROL SYSTEM							
1	Verify function of the general crane control systems and components thereof		X ²				

PREVENTIVE MAINTENANCE TASKS FOR CRANES

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
2	Verify function and adjustment of the lower-limit switch (as applicable) and verify that at least two full wraps of wire rope remain on the drum at the lower limit.		X ²				
3	Verify function and adjustment of the upper-limit switch and verify proper wire rope spooling on drum.		X ²				
3	Check function of brake control circuits for bridge, trolley, main & auxiliary hoist		X ²				
5	Check for proper operation of all electrical safety devices including emergency stop switches.		X ²				
6	Check all lights for proper operation.		X ²				
7	Inspect to verify that all wiring and connections are in good condition					X	
8	Ensure that required control labels as present and are legible					X	
9	Inspect contactor contacts for signs of deterioration and overheating					X	
10	Inspect levers and cams, ensure adequate lubrication					X	
11	Visually examine resistor tubes for cracks, loose bands and connections, and broken resistance wire.					X	
12	Clean resistor banks if dirty.					X	
	ROPE, DRUMS, SHEAVES, HOOKS, LOAD CHAIN						
1	With a sheave gauge, check grooves of drums and sheaves for wear					X	
2	Inspect load block guards for contact with sheaves or wire rope					X	
3	Inspect wire rope dead-ends.					X	
4	Inspect the end connections.					X	
5	Visually inspect hoisting rope or chain for damage, wear, and proper lubrication.		X ²				
6	Visually inspect hoist rope or chain for proper reeving and spooling		X ²				
7	Run-out the rope or chain to visually examine those portions that flex over sheaves, sprockets, and other areas subject to wear or abrasion.					X	
8	Inspect wire ropes		X ²				
9	Clean and lubricate wire rope, sheaves and drums					X	
10	Verify hoist chain feeds smoothly into and away from sprockets.		X ²				
11	Inspect hooks for wear, cracking, corrosion and deformation.		X ²				
12	Verify function of hook latches		X ²				
13	Verify that swivel hooks are free to rotate		X ²				
14	Lubricate swivel and sheave bearings as required.					X	
	BRAKES						
1	Ensure that brakes are functioning normally and that there is no slippage, excessive play, or binding.		X ²				
3	Check operation of drive system, bridge and trolley brakes and look for leaks in hydraulic lines		X ²				
4	Clean dust and dirt from brakes					X	
5	Check brake lining for excessive wear and oil contamination. Inspect for signs of heating.		X ²				
6	Measure and record brake shoe clearance and thickness.					X	

PREVENTIVE MAINTENANCE TASKS FOR CRANES

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
7	Adjust brake shoe clearance					X	
8	Check brake drums for scoring and wear					X	
9	Lightly lubricate brake pivot points					X	
10	Inspect brake fluid level		X				
	GEARBOXES, DRIVE SYSTEMS						
1	Check mounted bearings for tightness, wear, and proper lubrication.					X	
2	Listen for abnormal noise in gear boxes and motors		X ²				
3	Inspect oil and gear boxes for metal and nonmetallic particles.					X	
4	Check oil seals for leaks					X	
5	Inspect gears for missing or worn teeth, abnormal wear patterns and excessive heat					X	
6	Ensure proper lubrication of gearboxes, bearings, etc					X	
7	Inspect condition of shafts and couplings					X	
8	Inspect condition of all protective guards					X	
9	Check that drive chain feeds into and away from sprockets smoothly		X ²				
10	Inspect drive chain for stretch, wear, corrosion, and other damage		X ²				
11	Inspect roller type drive chain under load in lifting and lowering directions, observing for smooth feed of chain into and away from the sprockets					X	
12	Inspect roller type drive chain for damage, corrosion, etc.					X ²	
13	Clean and lubricate roller type drive chain					X	
	MOTORS						
1	Perform an infrared scan of the motor					X	
2	Clean and inspect motor brushes for wear and slip rings for pitting					X	
3	Inspect commutators for wear, flat spots, high bars, discoloration, or ridging					X	
4	Check connections to brushes, verify tightness and look for signs of excessive heat					X	
5	Clean motor air intake screens					X	
6	Ensure motor bearings are properly lubricated					X	
	POWER SUPPLY						
1	Check the contact surfaces of open conductors and collectors for signs of arcing damage, pitting, and corrosion.					X	
2	Clean insulators and check their condition					X	
3	Check that festoon type conductor cable moves freely with bridge and trolley movement.					X	
4	Inspect power cables and control pendants					X	

1. As determined by engineer or manufacturer.
2. Before each use, otherwise monthly.

Appendix F

DC System Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR DC SYSTEMS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
1	Verify presence and function of safety systems		X				
2	Perform visual inspection					X	
	BATTERY						
1	Check for unintentional grounds & condition of battery rack		X				
2	Check ventilation, temperature, & humidity control systems		X				
3	Perform capacity/load test						5
4	Inspect electrical connections and wiring					X	
5	Check electrolyte level of each cell			X			
6	Check Battery Voltage		X				
7	Check Cell Voltage			X			
8	Check Intercell Resistance					X	
9	Check specific gravity		X				
10	Check cell water level		X				
11	Inspect cell posts for corrosion/continuity					X	
12	Check tightness of intercell connections					X	
	BATTERY CHARGER						
1	Check output voltage		X				
2	Clean any accumulated dust, dirt.		X				
3	Inspect electrical connections and wiring					X	
4	Verify output waveform						5
5	Verify function of current limiter						5
6	Check for annunciation					X	
	SWITCHGEAR (SEE ALSO BREAKERS)						
1	Inspect electrical connections and wiring						5
2	Clean any accumulated dust, dirt.						5
	SWITCHBOARDS						
1	Inspect electrical connections and wiring						5
2	Clean any accumulated dust, dirt.						5
	BATTERY MONITORING SYSTEM						
1	Inspect unit for indication of abnormal battery conditions	X					
2	Reconcile monitoring system indicated values with manual			X			
3	Backup monitoring system data		X				
4	Clean any accumulated dust, dirt.					X	
5	Inspect electrical connections and wiring					X	
	INVERTER						
1	Check input/output voltages						5
2	Check system load						5
3	Inspect electrical connections and wiring					X	
4	Clean any accumulated dust, dirt.					X	
	CONTROL CIRCUITS						
1	Inspect electrical connections and wiring						5
2	Function test protection circuits						5

Appendix G

Diesel Generator Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR DIESEL GENERATORS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
1	Check engine oil level; add as required		X				
2	Check battery charge and electrolyte specific gravity; add water as required. Check terminals for corrosion; clean as required		X				
3	Check belts for wear and proper tension; adjust as necessary		X				
4	Check that crank case heater is operating		X				
5	Check wiring, connections, switches, etc.; adjust as required		X				
6	Perform 30 minute generator test run; check for proper operation		X				
7	Check fuel level with gage pole, add as required		X				
8	Wipe dust and dirt from engine and generator		X				
9	Clean area around generator		X				
10	Change engine oil and oil filter					X	
11	Check engine air filter; change as required					X	
12	Check injector nozzle condition; service or replace as required						5
13	Check engine coolant level and radiator system		X				
14	Clean crankcase breather				X		
15	Examine Radiator Hoses				X		
16	Flush cooling system, replace filter					X	
17	Perform load test			X			
18	Check engine valve clearance						5
19	Inspect fuel tank and filters					X	
20	Clean fuel tank						10

Appendix H

Disconnect Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR DISCONNECTS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
1	Inspect insulators.					X	
2	Inspect connections.					X	
3	Verify proper seating and alignment.					X	
4	Check simultaneous closing of all blades.					X	
5	Clean insulators.					X	
6	Insulator power factor test					X	
7	Manually operate.					X	
8	Infrared scan.					X	
9	Verify full travel.					X	
10	Inspect interphase linkages.					X	
11	Check gearboxes for moisture.					X	
12	Verify grounding connections of platform and operating handle.			X			
13	Inspect bolts, nuts, washers, cotter pins, and terminal connectors.					X	
14	Inspect arcing horn.					X	
15	Visually inspect contact points.					X	
16	Inspect enclosure (as applicable)					X	
	LOAD BREAK DISCONNECTS						
1	Inspect arc chutes					X	
2	Check arcing fingers and blades					X	
3	Operate manually and verify opening and closing alignment					X	
4	Lubricate moving parts					X	
5	Inspect bolts, nuts, washers, cotter pins, and terminal connectors.			X			
6	Check gears for damage			X			
7	Clean bearings					X	
8	Check simultaneous closing of all blades.					X	
	CIRCUIT SWITCHERS						
1	Check interrupter operation					X	
2	Check and adjust switcher linkages					X	
3	Check proper operation and adjustment of limit switches					X	
4	Lubricate gears					X	
5	Check gearmotor					X	
6	Inspect for oil leaks					X	
	MOTOR OPERATORS						
1	Check condition of enclosure					X	
2	Check for moisture					X	
3	Check proper operation of space heaters					X	
4	Check fuses and fuse clips					X	
5	Verify proper operation and adjustment of limit switches					X	
6	Manually operate.					X	
7	Lubricate gears					X	

Appendix I

Exciter Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR EXCITERS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
1	Inspect cabinet air filters and replace as necessary.		X				
2	Infrared Scan					X	
3	Examine operating and control mechanism for proper condition. Observe for proper operation when unit is on regulator control.					X	
4	See that indicating lights, dampening elements, transfer switches and adjusting rheostats are in condition to insure good operation.					X	
5	Repair, replace and adjust components as prescribed in the manufacturer's instructions to provide good operation.					X	
6	Swap from Auto to Manual and verify seamless transfer					X	
7	Drive VARs to over and under excitation limits and verify operation of limiter					X	
8	Check power system stabilizer in proper operation mode	X					
9	Check and calibrate meters						See Meters
10	Exciter overcurrent relay testing						See Relays
11	Verify alarm and trip circuits						5
12	Clean exciter cabinet					X	
13	Check power leads for abrasions/cuts/general condition					X	
14	Check failover of redundant components					X	
15	Model Verification/Performance Testing						5
16	Blackstart test					X	
	BASES AND SUPPORTS						
1	Inspect for loose bolts, dowel pins or other defects. Repair as necessary.					X	
2	Check frame grounding, repair as necessary.					X	
	COLLECTOR RINGS						
1	Check wear, note color. Polish or recondition to assure proper operation.					X	
2	Inspect brush rigging for loose bolts, connections and defective springs.					X	
3	Check condition of brushes and fit. Tighten repair or replace as needed.					X	
4	Test spring tension. Record tension pressure.					X	
5	Brush Rigging: On generators of 500 kilowatts or synchronous motors of 500 horsepower and above, reverse field polarity.						5
6	Visually inspect brushes for correct length and proper contact. Adjust as necessary.					X	
7	Examine contact points and burnish as needed. Inspect pivot points for free movement.					X	
	COLLECTOR HOUSING						
1	Clean out dust and dirt.					X	
	COIL WINDING						
1	Inspect condition of exposed parts of windings, insulation, connections, clamps, end turn lashing and related items.					X	
2	Examine for loose taping, mechanical damage, presence of oil or dirt. Clean, repair and recoat with suitable insulating compound where necessary.					X	
3	Measure air gap clearances and record					X	
	ROTOR						
1	Check the bus connections and power cable terminations for heating and loose connections.						During Main Unit Outage

PREVENTIVE MAINTENANCE TASKS FOR EXCITERS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
2	Inspect insulators and supports for breaks, cracks, or burns.						During Main Unit Outage
	EXCITATION BREAKER						
1	Perform visual inspection of excitation breaker						See Breakers
2	Check contact resistance						See Breakers
3	Perform breaker timing test						See Breakers
4	Check electrical connections for tightness						See Breakers
	FUSES						
1	Inspect fuses and fuse holders					X	
	DE-EXCITATION/CROWBAR (DXCB) MODULE						
1	Check thyristors					X	
2	Perform visual inspection					X	
	FAN BLOWER/MOTOR						
1	Verify fan failure annunciation		X				
2	Inspect the blower motor for excessive vibration and noise. If excessive check for damaged or worn bearings.		X				
3	Clean the motor/blower.					X	
4	Check the blower motor controller, and control wiring for signs of heating, loose terminations and contactor wear.					X	
5	Check for loose blower mountings.					X	
	GROUND DETECT MODULE						
1	Test the ground detector module.					X	
	PROTECTIVE RELAYS						
1	Check the protective relay calibration						See Relays
	SHAFT SUPPRESSION						
1	Inspect shaft suppression ground brush and associated circuitry					X	
	SPACE HEATER						
1	Ensure function of cabinet heaters	X					
	FIELD FLASHING CIRCUIT						
1	Check the condition of the DC field flashing contactor and arc chute.					X	

Appendix J

Fire Prevention Systems Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR FIRE PREVENTION SYSTEMS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
GENERAL							
1	Perform visual inspection of system and individual components					X	
2	Test fire detection devices					X	
3	Test alarm initiating devices and associated control circuits					X	
4	Check electrical connections for tightness and condition.					X	
5	Check indicating devices and associated annunciation circuits.					X	
6	Check backup power on detection devices					X	
7	Check operation of hydrants					X	
8	Check condition of fire hoses					X	
9	Check condition of fire extinguishers		X				
WATER SUPPRESSION SYSTEMS							
1	Verify operation of valves					X	
2	Test insulation resistance of fire pump motors					X	
3	Perform IR inspection of motors					X	
4	Verify lubrication of fire pump and motor					X	
5	Verify alignment of motor-pump coupling					X	
6	Verify operation of discharge heads					X	
7	Check piping system for leaks					X	
8	Perform a complete system function test					X	
9	Test initiating devices and associated control circuits.					X	
CARBON DIOXIDE SUPPRESSION SYSTEMS							
1	Verify operation of valves					X	
2	Verify operation of initiating devices					X	
3	Verify adequate supply of Low Pressure CO2		X				
4	Verify adequate supply of high pressure CO2					X	
5	Verify operation routing valve control circuits.					X	
6	Verify operation air exhaust baffles in protected areas.					X	
7	Verify operation of dampers					X	
8	Verify operation of door releases					X	
9	Verify operation of motor cut-out circuits.					X	
10	Verify function of pressure switches, transducers, etc.					X	
11	Hydrostatic test storage bottles						3
12	Test initiating devices and associated control circuits.					X	
13	Pressure test or replace flexible hoses						5
14	Inspect low pressure CO2 tank						5

Appendix K

Generator Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR GENERATORS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
GENERAL							
1	Visual examination for condition of surge protective equipment.					X	
2	Measure shaft and coupling runout					X	
3	Visually examine bus assemblies, insulators, and supports for good condition.	X					
4	Visually examine enclosures for condition.	X					
5	Observe visible portions of cables to determine condition, paying particular attention to shielding and metallic-sheathed cables operating at 5 KV or above.	X					
6	Insulation: PDA Test					X	
7	Insulation resistance, polarization index (Megger)					X	
8	CT relaying & metering: Burden Tester						2
9	Time integrated meters: Statistical test					X	
10	Overall: Frequency response test (offline) - MODEL VERIFICATION						5
11	MW testing and/or verification (online)					X	
12	Review equipment ratings						5
13	Demonstrate system restoration plan performance					X	
15	Clean air housing above and below, dust/brake dust, etc					X	
16	Perform air gap measurements						5
17	Perform stator/rotor roundness measurements						5
GENERATOR AIR COOLERS							
1	Flush coolers.					X	
2	Clean exterior surfaces of coils and check for leaks.					X	
3	Check interior of coils for excessive scale buildup					X	
4	Operate isolation valves					X	
5	Inspect plumbing/piping for leaks	X					
6	Check operation of vacuum breakers		X				
7	Check temperature monitoring devices					X	
GENERATOR BRAKES							
1	Measure brake shoe thickness and check condition of brake ring.					X	
2	Operate brake cylinders to check for any binding, leaking, or sticking. Verify brakes applied indication.					X	
3	Exercise isolation valves					X	
4	If lubricator is not installed, operate unit jacks to lubricate brake cylinders					X	
5	Check condition of brake air line filters.		X				
6	Check condition of brake lubricators (if installed)		X				
JACKING PUMP SYSTEM							
1	Visually inspect motor/pump shaft alignment for excessive runout or vibration. Look for loose coupling bolts or other damaged coupling components.					X	
2	Lubricate if required.					X	
3	Check for leaks from casing at gasketed joints and tighten or replace gaskets as required.					X	
4	Verify pump motor full load amps					X	
5	Check operation of valves and gauges					X	
6	Check strainers and filters					X	
7	Check piping for leaks					X	
THRUST BEARING							
1	Take oil sample for analysis					X	

PREVENTIVE MAINTENANCE TASKS FOR GENERATORS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
2	Verify/calibrate high lift permissive device					X	
3	Calibrate temperature sensors and oil level indicators. Verify annunciators					X	
4	Check operation of thrust bearing high-pressure lubrication system oil pumps.		X				
5	Check filters on high-pressure lubrication system and clean or replace as required.		X				
6	Check insulation resistance					X	
7	Check system for leaks	X					
8	Verify pump motor full load amps					X	
9	Check/verify/inspect gauges and valves	X					
10	Check failover of redundant systems		X				
11	Visually inspect motor/pump shaft alignment for excessive runout or vibration. Look for loose coupling bolts or other damaged coupling components.		X				
12	Verify proximity probe sensors					X	
	GUIDE BEARING						
1	Take oil sample for analysis					X	
2	Check bearing clearances						5
3	Calibrate temperature sensors and oil level indicators. Verify annunciators					X	
4	Check insulation resistance					X	
5	Check system for leaks	X					
6	Check/verify/inspect gauges and valves	X					
7	Verify proximity probe sensors					X	
	ROTOR						
1	Visually inspect rotor spider for cracks					X	
2	Visually inspect field poles and connections					X	
3	Perform Insulation Resistance/Polarization Index Test						5
4	AC pole drop test						5
5	Field winding AC impedance						5
	STATOR						
1	Inspect stator core for loose laminations, loose clamping bolts, fretting, etc.					X	
2	Inspect stator windings for insulation damage					X	
3	Perform power factor test						5
4	Perform Insulation Resistance/Polarization Index Test						5

Appendix L

Governor Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR GOVERNORS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
GENERAL							
1	Inspect system for leaks	X					
2	Take oil sample for analysis.					X	
3	Inspect and clean governor cabinet components		X				
4	Exercise governor hand valves and check for leaks					X	
5	Clean and inspect all filters/strainers.			X			
6	Inspect and clean interior of governor oil pressure tanks and sumps.						5
7	Disassemble, clean, and inspect oil pumps and replace all worn parts.						5
8	Check lighting, gratings, floor plates, etc., for good condition.	X					
9	See that access doors and plates are tight and fit properly.	X					
10	Inspect anchor bolts for indications of looseness.		X				
11	Verify calibration of temperature, level, pressure, flow, and position transducers.					X	
12	Measure and record full gate opening and closing time and the cushioning stroke time.					X	
13	Check operation of brake circuit.					X	
14	Verify tightness of all electrical connections.					X	
15	Test insulation between the PMG/SSG and its support casting.					X	
16	Test underspeed and overspeed trip devices and record the tripping speed.					X	
17	Perform system function check.					X	
18	Inspect all governor system gages, indicator lights, instruments, speed-no-load and shut-down solenoids, remote controls, remote indicators, pressure relays, safety valves, and auxiliary switches.					X	
19	Verify annunciation and trip circuits.					X	
20	Change filters on purification system.					X	
21	Exercise valves.					X	
22	Inspect condition of piping and check for leaks.					X	
MECHANICAL GOVERNOR							
1	Lubricate linkage and pivot pins.		X				
2	Inspect/lubricate restoring cable mechanism, bushings, and pins				X		
3	Inspect and adjust dashpot.					X	
4	Inspect, measure, and record PMG rotor clearances.					X	
5	Inspect, measure, and record flyball rotor clearances.					X	
6	Measure resistance of insulated joints for restoring cable where provided.					X	
7	Observe for signs of loosening or damage to dowel pins.					X	
DIGITAL GOVERNOR							
1	Inspect PLC battery					X	
GOVERNOR ACCUMULATOR TANK							
1	Check operation of clapper valve.					X	
2	Clean and inspect the interiors/exterior of the pressure tanks and sump tanks.						5
3	Clean and inspect sight glasses.					X	
4	Inspect and calibrate pressure relief valve.					X	
GOVERNOR OIL PUMP							

PREVENTIVE MAINTENANCE TASKS FOR GOVERNORS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
1	Visually inspect condition of governor oil pump.	X					
2	Verify shaft coupling alignment.					X	
3	Check motor full load amps.					X	
4	Perform infrared scan of motor.					X	
5	Check for proper lubrication of governor oil pump.	X					
6	Check insulation resistance of governor oil pump motor.					X	
7	Verify proper operation of unloaders.					X	
	SERVOMOTORS						
1	Conduct visual inspection of servomotor condition and check for leaks.	X					
2	Inspect servomotor, shift ring, and wicket gate linkage for proper operation.	X					
	SPEED SIGNAL GENERATOR						
1	Inspect speed switches and drive gears for wear.					X	
2	Lubricate pivot pins and check speed switch bearings.					X	
3	Check insulation between PMG/SSG housing and the supporting frame.					X	
4	Verify voltage output of PMG.					X	
5	Verify speed switch setting.					X	

Appendix M

Relay and Meter Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR RELAYS AND METERS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	METERS						
1	Verify meter accuracy with a known source.					X	
	RELAYS						
1	Perform fault load studies and recalculate settings.						5 yrs
2	Perform a comprehensive inspection					X	
3	Activate the lockout relay from each protective device. ¹						5 yrs ²
4	Verify the lockout relay and/or subsequent devices actually tripped from the protective relay action. ³						5 yrs ²
5	Test initiating devices to relays						5 yrs ²
6	Perform lubrication and/or replacement of Lock Out Relays actions.						2 yrs
7	Settings Verification						2 yrs
	Electromechanically Relays						
8	Operational Test & Calibrate						5 yrs ²
	Microprocessor Relays						
9	Pull and Analyze Relay Event Reports			X			
10	Input/Output Verification Tests						5 yrs ²
11	Measurement Channel Tests						5 yrs ²

NERC Applicability:

Protection Systems that act to trip the generator either directly or via lockout or auxiliary tripping relays.

Protection Systems for generator step-up transformers for generators that are part of the BES.

Protection Systems for transformers connecting aggregated generation, where the aggregated generation is part of the BES (e.g., transformers connecting facilities such as wind-farms to the BES).

Protection Systems for station service or excitation transformers connected to the generator bus of generators which are part of the BES, that act to trip the generator either directly or via lockout or tripping auxiliary relays.

Notes:

After the first full test of lockout relay and breakers, it may be desirable to lift the trip bus from the lockout relay so as not to repeatedly

¹ trigger the lockout—a meter may be substituted to verify contact initiation.

² 6 years or 12 years if monitored required by NERC PRC-005

³ Remove control heads from CO₂ bottles, initial and delay, before testing.

Appendix N

Transformer Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR TRANSFORMERS
 Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
 (Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
GENERAL							
1	Perform visual inspection of enclosure and external equipment		X				
2	Clean bushings and insulators					X	
3	Check electrical connections and wiring					X	
4	Verify operation of annunciation devices and circuits					X	
5	Verify operation of control circuits					X	
6	Verify overall operation and condition of cooling equipment/system					X	
7	Inspect fan blades					X	
8	Measure motor full load amps					X	
9	Check insulation resistance of motors						4
10	Inspect motors for excessive vibration		X				
11	Inspect motors for proper lubrication					X	
12	Perform power factor test of bushings and insulators						4
13	Perform power factor test of winding						4
14	Perform turns ratio test						4
15	Perform winding resistance test						4
16	Perform excitation current test						4
17	Perform Capacitance Test						4
18	Perform sweep frequency response analysis						4
19	Verify operation of cabinet heaters	X					
20	Verify function/exercise tap changers						4
21	Verify grounding connections					X	
22	Check calibration and verify operation of temperature, pressure, and flow indicating devices					X	
OIL INSULATED TRANSFORMERS							
1	Sample oil and perform dissolved gas analysis					X	
2	Check calibration of oil level indication devices					X	
3	Check oil level		X				
4	Inspect piping		X				
5	Check for proper oil flow.		X				
6	Inspect valves and verify proper operation					X	
7	Check heat exchangers for adequate air/water flow		X				
8	Verify overall operation of fire suppression system					X	
9	Test fire suppression initiating devices					X	
10	Verify operation of mechanical pressure relief device						4
11	Verify operation of sudden pressure device						4
12	Inspect conservator and bladder						4
13	Verify nitrogen type and overall operation of nitrogen system		X				
14	Verify nitrogen system pressures and proper operation of regulators		X				
15	Inspect nitrogen system for leaks	X					
16	Inspect transformer for oil leaks	X					
17	Inspect oil containment for leaks	X					
18	Inspect oil containment drains for blocks	X					
19	Function test Buchholz relay						4
20	Drain water from oil containment	X					
DRY TYPE TRANSFORMERS							
1	Perform visual inspection of winding and internal components		X				
2	Clean accumulated dust and debris from winding and enclosure					X	
3	Check internal connections and wiring					X	

PREVENTIVE MAINTENANCE TASKS FOR TRANSFORMERS
Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	CURRENT TRANSFORMERS						
1	Verify that current signal values are provided to the protective relays						2
	VOLTAGE TRANSFORMERS						
1	Verify that voltage signal values are provided to the protective relays, meters and instruments						2
	BUSHINGS						
1	Clean all exterior surfaces					X	
2	Visually inspect for cracks, corrosion, and leaks		X				
3	Inspect gaskets						4
4	Inspect capacitance taps and test electrodes.						4
5	Check oil level.					X	
6	Perform Power Factor Test.						4
7	Perform Capacitance Test						4
	TAP CHANGER - NO LOAD						
1	Visually inspect					X	
2	Check contact pressure and alignment.						4
	TAP CHANGER - LOAD						
1	Visually inspect.					X	
2	Check contact pressure and alignment.						4
3	Check Position Indicating Devices and associated control circuits.					X	
4	Perform Timing Test						4

Appendix O

Turbine Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR TURBINES

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	DRAFT TUBE DEPRESSION AIR						
1	Test air control circuit operation.					X	
2	Check connections, terminals and controls.					X	
3	Check float switch operation.					X	
4	Check transducer calibration.					X	
	TURBINE GUIDE BEARING						
1	Visually check shaft and coupling for excessive runout or vibration.					X	
2	Visually inspect piping and check system for leaks.					X	
3	Check motor full load amps.					X	
4	Check controls, wiring, terminals, and connections.					X	
5	Check annunciations.					X	
6	Check/verify calibration on temperature, level, pressure, and flow measurement devices.					X	
7	Inspect oil strainers and clean					X	
8	Sample and analyze oil					X	
9	Check oil level.	X					
10	Inspect heat exchanger.						5
11	Verify calibration of proximity probes.						5
12	Check bearing bracket and fasteners.					X	
	HEAD COVER						
1	Check pumps and piping for leaks.					X	
2	Take motor full load amps.					X	
3	Verify function of high water alarm and pump control circuit.					X	
4	Inspect the vacuum breaker.						5
5	Add oil to the vacuum breaker snubbers					X	
6	Inspect head cover fastener condition					X	
7	Inspect head cover condition.					X	
	SHAFT SEAL						
1	Check shaft seal lubricant flow and pressure measuring devices.	X					
2	Inspect shaft seal for excessive leakage and adequate lubrication.	X					
3	Evaluate condition/remaining life of shaft seal medium					X	
4	Inspect shaft seal fastener condition.					X	
5	Inspect shaft seal component condition.					X	
	TURBINE RUNNER						
1	Examine runner/hub thoroughly for cavitation or other damage						5
2	Inspect wear rings. Measure clearances.						5
3	Check runner seal lubricant flow and pressure measuring devices.					X	
4	Check blade seals and nose cone for leakage.						5
5	Check for blade clearance and droop.						5
6	Confirm blade angle travel.						5
	BUSHING						
1	Verify function of centralized greasing system.		X				
2	Check operation counter of automatic centralized greasing system for operating cycles.		X				
3	Grease bushings not covered by centralized greasing system					X	

PREVENTIVE MAINTENANCE TASKS FOR TURBINES

Weekly (W), Monthly (M), Quarterly (Q), Semi-Annually (S), Annually (A), Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
4	When unit is unwatered, operate system to determine that all points are receiving an adequate supply of lubricant.						5
5	Check for excessive or inadequate greasing						5
6	Clean up excessive grease					X	
7	Check for signs of excessive bushing wear					X	
8	Check grease system piping/joints for leaks					X	
	WICKET GATES						
1	Inspect wicket gate linkages, shear arm, gate arm, thrust cap						5
2	Check the eccentric bushing retainer bolts on each wicket gate arm.					X	
3	Check for broken shear pins in all of the wicket gates.		X				
4	Check shear pin annunciation system is functional					X	
5	Clean out the wicket gate stem pockets.					X	
6	Check the gate stem seal for excessive leakage.					X	
7	Check all of the wicket gate operating linkage for loose keys, pins, or bolts.					X	
8	Check wicket gate position indication vs servo stroke					X	
9	Measure wicket gate clearances						5
10	Inspect facing plates for evidence of galling						5
11	Inspect gates for smooth operation						5
12	Verify condition of wicket gate end seals						5
13	Inspect wicket gates for cavitation, cracking, excessive						5
	STAY VANES/RINGS						
1	Inspect stay vanes/rings for cavitation, cracking, excessive wear, corrosion						5
	OPERATING RING						
1	Inspect operating ring for smooth operation, signs of distortion or abnormal movement					X	
2	Inspect condition of operating ring for signs of cracks, excessive wear, corrosion					X	
	TURBINE SHAFT						
1	Inspect shaft coupling bolts					X	
2	Inspect Kaplan piston weep hole in shaft					X	
3	Inspect coupling bolt guard fasteners					X	
4	Inspect turbine coupling bolts					X	
5	Inspect, clean, and oil shaft					X	
6	Check shaft run out					X	
	DRAFT TUBE LINER						
1	Check condition of interior coating						5
2	Check condition of draft tube liner for evidence of corrosion, erosion, runner contact, and cavitation						5
3	Inspect riveted and welded joints for leaks and corrosion						5
4	Check condition of man doors, hinges, and fasteners						5

Appendix P

Water System Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR WATER SYSTEMS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

This covers raw water supply systems for cooling water systems, systems used for generator cooling, compressor cooling, hvac source, fire protection source, etc

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
1	Verify flow and pressure are within system requirements		X				
2	Verify function of gauges, sensors and switches					X	
3	Verify annunciation to the control room					X	
4	Check floats for proper level and operation					X	
5	Megger electric motors and record results					X	
6	Clean strainers			X			
7	Flush/clean supply and drain lines					X	
8	Open tank drain to flush until water is clear		X				
9	Exercise isolation valves					X	
10	Check valves, piping, tanks, gauges and appurtenances for leaks					X	
11	Ensure proper lubrication of pumps, shafts, bearings		X				
12	Check raw water pump packing		X				
13	Grease motor and pump bearings & check same for overheating		X				
14	Check 'air-add' system for proper operation					X	
15	Inspect condition of access					X	
16	Inspect ground drainage slope and vent screens, where applicable					X	
17	Inspect tank lighting system					X	